HOD LIPSON
Cornell University

Autonomous Self-Extending Machines for Accelerating Space Exploration

The rate at which we explore planets is tightly linked with the rate at which we are able to successfully complete robot deployment cycles. Judging from past experiences of Mars and lunar explorations, the design-fabricate-test-deploy cycle takes an order of a few years to complete at least. The approach advocated here shifts the focus from designing and launching the ultimately capable and robust robot, to launching a fabrication system that can fabricate and recycle task-specific robots in the field, as well as extend its own capabilities. In this vision, a self-contained fabrication facility is launched with initial material and component stock. Tested blueprints are transmitted subsequently for fabrication on site, as appropriate to exploration state and findings. Materials and components recycled from the original spacecraft, unused robots and in-situ resources of energy and material are used to construct newer machines as required. The focus of this proposal is on the architecture of a 100% automatic, self-contained and versatile fabrication process, capable of autonomously producing an entire working machine with no human intervention. This proposal is well grounded in physics of new multi-functional materials and free-form fabrication, yet the focus on fully autonomous fabrication of complete systems is a uniquely new and enabling challenge that has not been addressed before. This phase will deliver two parts: (a) architecture of a fully autonomous deployable self-extending machine, along with a comprehensive study of required functionalities and candidate materials and components, and (b) an evaluation of architecture through a limited concept implementation. The goal is to allow an informed assessment of the merits of this approach, and decision as to pursuing a second phase of investigation validating fully autonomous fabrication of complete working robots involving actuation, sensing and logic. This research will help NASA achieve its goal of completing missions more frequently, less expensively, and with greater flexibility.